Cold-weather-revised-syllabus for PHY 201: Space, Time and Motion Spring 2019

Introduction

What does it mean for an object to be truly in motion? In this course, we will engage in a careful study of dynamics—the science of the causes of motion and rest—paying particular attention to the ideas of space and time. We will focus on reading selections from Galileo's *Dialogues*, Pascal's *Physical Treatises*, Newton's *Principia* and Einstein's *Relativity*. Weekly laboratory sessions complement our classroom discussions. 4 lec. 3 hrs. lab.

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Course Times and Locations

Lec. 1: S109, MWF 10:30 - 11:20, R 11:30-12:20
Lec. 2: S115, MWF 9:00 - 9:50, R 1:00-1:50

Lab. 1: S115, W 12:30 - 3:20, Dr. Davis
Lab. 2: S115, R 12:30 - 3:20, Dr. Davis
Lab. 3: S115, F 12:30 - 3:20, Prof. Schindler
Lab. 4: S115, R 8:00 - 10:50, Dr. Davis

Grade components

Classroom discussion	10%	Laboratory discussion	10%	Midterm exam 2	20%
Laboratory exercises	15%	Midterm exam 1	20%	Final exam	25%

Grading scale

A	100-93%	B	87-80%	C	74-70%	D	61-54%
AB	92-88%	BC	79-75%	CD	66-62%	F	53-0%

Course objectives

- understand nature—(specifically the science of moving bodies)
- improve reading comprehension and vocabulary—(through the reading and discussion of great texts)
- discern truth from error—(by analyzing and comparing the best ideas which have been written)
- articulate scientific ideas—(both verbally and in written form)
- solve problems—(conceptual, mathematical, experimental)
- provide a suitable foundation for advanced coursework in physics (talk to me about major or minor)

Required Textbook

Kerry K. Kuehn, A Student's Guide through the Great Physics Texts, Volume II: Space, Time and Motion . Springer (2015). ISBN 978-1-4939-1365-7

Examinations

There will be three examinations in this class. To best prepare for the exams, you should

(1) read all of the *assigned reading* selections completely—(at *least* once),
(2) use the *study guide* after each reading—(to be sure you understand key points in the readings),
(3) participate in *classroom discussions*—(use our classroom discussion to figure out what you don't understand in the readings)
(4) work through the recommended *homework exercises*—(*before* resorting to the posted solutions),
(5) *study the solutions* to the exercises—(to be sure you don't make the same mistakes twice),
(6) learn the *vocabulary words*—(to help with reading comprehension and overall literacy),
(7) review the *laboratory exercises*—(some exam questions may be based on what you did in lab), and
(8) regularly *visit me* during office hours to discuss physics—(I am a very nice person)

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Reading and discussing the great texts

In this course, we will read and discuss some of the classic scientific texts dealing with the motion of bodies—whether they be rocks falling through fluids or planets hurtling through outer space. The scientific texts we will read are considered classics because they address timeless questions in a particularly honest and convincing manner. This does not mean that everything they say is true—in fact many classic scientific texts contradict one another—but it is by the careful analysis of the most reputable observations and opinions that one may begin to discern truth from error.

You will not understand everything you read. Nobody does. The texts are challenging. Like great literature, these texts must be ``grown into", so to speak. So think of this course as a ``first dip" into the deep end of the pool. They are classic texts because—like fine wine—both the beginner and the advanced scholar can profit by studying them.

The time that we spend in the classroom will be devoted to discussion of the reading selections. As the discussion leader, I will typically ask questions regarding specific ideas which are found in the texts. For instance, I may ask, "What does the author mean by the term *weight*," or "Is it true that all matter has weight?" And if so, "How do you know?" The task will then be to try, as a group, to answer these questions.

It is critical that participants carefully read the assigned selections before engaging in discussion. This will help participants to make relevant comments and to cite textual evidence to support or contradict assertions made during the course of the discussion. In this way, many assertions will be revealed as problematic, in which case they must then be refined or rejected altogether. This is precisely the method used by scientists themselves in order to discover and evaluate competing ideas or theories.

Classroom discussion: étiquette and grading

During our discussion, you may speak with complete freedom. There is only one rule: *any comment or question you make must be made publicly so that all others can hear and respond*.

Each student will receive a discussion grade for the class which will range from 0% to 100%. I will notify you of your discussion grade when I return each midterm exam. To clarify how I approach classroom discussion grading, consider the following examples.

- The 100% student is actively engaged in the classroom discussion. His or her ability to raise interesting and relevant points from the text is evidence that they have studied the assigned text and put significant thought into analysis outside of class.
- The 80% student is somewhat engaged in the classroom discussion. He or she makes comments or raises questions during the discussion, but they have some trouble providing specific textual or rational support for their assertions.
- The 60% student is very occasionally engaged in the classroom discussion. They sit silently but politely. They may have read the assigned text, but have not thought enough about it to formulate any coherent thoughts. They uncritically accept whatever is said by the author, the instructor and the other students in the class.
- The 0% student comes to class, but instead of presenting his or her views to the class publicly, they whisper them to their friends. The instructor and other students find this distracting and a bit rude.

From an instructor's perspective, discussion is admittedly the most difficult grade to assign, as it is unavoidably somewhat subjective. Nonetheless, learning to verbally articulating scientific ideas in a public setting is an important skill and one of the secondary learning objectives of this course.

Most students are initially apprehensive about engaging in public discussion. This is natural. If you find yourself to be one of these it is important to realize that you do not need to make an elaborate point in order to engage in classroom discussion. Often, a short question can provide a simple avenue. For example, ``I am unclear what the author means by the term *celestial*. Can someone please clarify?" Write down questions like these in the margins while reading the text. Start like this. Pretty soon, you may find yourself joining gamely in classroom discussion.

Laboratory exercises

Many reputable opinions regarding how nature works are wrong. In many cases, this is because these opinions do not conform to the way nature actually behaves. How can one determine how nature actually behaves? During our weekly laboratory session, we will cary out experimental investigations which attempt to reveal how nature works under controlled conditions. You will be provided with equipment and some general questions or suggestions related to the assigned reading for the week. It will be your responsibility to devise experimental techniques and procedures so as to clarify your understanding of nature.

Laboratory notebook

You must keep a record of your work during the laboratory sessions. To this end, you will need to purchase a lab notebook which must be brought to lab on your first laboratory session. Your lab notebook must be sturdy, must be at least 8.5 x 11 inches and must be quad-ruled (graph paper). You must allow the first few pages in your lab book to serve as a table of contents. The purpose of the lab book is to serve as a single source which contains all of the information relevant to your experiments. In particular, during each laboratory session, you should record the following information in your laboratory notebook:

- Your name and your laboratory partner's name, the date and a title for the experiment.
- A neat sketch of any experimental apparatus you use, along with labels (make and model).
- A clear description of your experimental procedure(s), including difficulties which you experienced in carrying out your experiments.
- Tables containing any data which you collect. You must never write data anywhere else: not on scrap paper, not on the back of your hand, nowhere. Also, you must write down an estimated uncertainty in any measurement which you perform. For instance, if you use a stop watch to time a falling ball, you should estimate the precision with which you were able to record the time. This is always slightly larger than the resolution of the device being used.

Your lab report must be written in blue or black ink. It must be written in chronological order. That is, you might first describe some of your procedure, then record some data, then describe some more of your procedure, then some more data , and finally do some analysis. The important thing is that you write clearly and that you spread out your writing so that the reader of your notebook can easily ascertain what you did, and reproduce it if necessary. If it contains computer printouts of data tables or plots, these must be trimmed to fit neatly on a page and secured with tape. Do not fold or stack your plots. All plots must occupy at least half of a laboratory book page (i.e. don't make tiny plots).

Before leaving the lab, your instructor will assign you a grade based on the neatness, clarity and completeness of your laboratory notebook.

Grading of the laboratory exercises

Each student will receive a weekly laboratory grade which will range from 0% to 100%. What follows are a few example students and the grade each received for one particular week.

- 100% students conceived of an appropriate experimental program and have systematically executed it. When they ran into difficulties, they were able to arrive at a reasonable solution or work-around. Their data is of good quality, and their analysis involves a reasonable assessment of sources of systematic error.
- 80% students conceived of an appropriate experimental program and have systematically executed it. Although they were able to complete his experiments, either their data was inconclusive, or their analysis involved a significant systematic error which for which they were unable to account.
- 60% students conceived of an appropriate experimental program, but were unable to complete significant portions of the laboratory assignment.
- 0% student completed little or none of the laboratory assignment.

Laboratory discussion sections

After collecting your data and performing some preliminary analysis, you will be prepared to share your experiments and your results with your classmates. Therefore, each week we will spend one class period discussing the

laboratory exercises. Each individual will be assigned a random week during the semester on which to do a formal presentation. The formal presentations must include:

- acknowledgement of the collaborators on your experiment
- description of the problem you were trying to solve, and how this relates to the week's lecture,
- a description of how you attempted to solve the problem, including a detailed description of your experimental apparatus and procedure,
- plots or tables of your data, along with a description of how you analyzed your data, and
- a summary of the significance of your laboratory work. It is not good enough to simply state your results without any analysis of their meaning. If your results are different than you had expected, then you must address this issue directly. This should include an analysis of any systematic errors. Be sure to distinguish between systematic and random errors.

The presentation should last no more than ten minutes, and will be followed by a short question and answer session. Be sure to bring visual aides that will allow others to get a clear look at you experimental setup and any data or plots you have prepared. The grade you receive will depend upon both the quality of your data and the extent to which you address the points mentioned in the previous section.

If you are not assigned to do a formal presentation, you should still bring your lab notebook to class to compare your method and results to those of the other groups. Our laboratory discussion sections will be aimed at understanding the meaning and significance of the experiments performed during lab sessions, and at discussing ways in which the experiments might have been performed so as to achieve the most meaningful results.

Final thoughts

I want to encourage you to come to me with any concerns you may have during the course of the semester, whether they be physics questions or difficulties with reading or discussion. This course is designed to challenge you, but not to "break" you. Reading the classics in any field is challenging, but very rewarding. I would very much like to help you succeed and to enjoy this class! My contact information is listed at the beginning of this syllabus, so please feel free to contact me!

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Semester Calendar (approximate)

Wk	2019 Dates (bold = no class;* = test)	Text	ASG Chapters & Topics	HW Exercises (**bold** = essay)	Lab Exercises
1	Jan **21**, 23, 24, 25	Galileo's *Dialogues*	1: Scaling in art and nature 2: The Coherence of substances	1.1, 1.2, 2.1, 2.2, 2.3	2.4
2	Jan **28**, **30**, 31, Feb. 1	Galileo's *Dialogues*	3: Archimedes' Principle and Falling Bodies	3.1, 3.2, 3.3,	Cancelled
3	Feb 4, 6, 7, 8	Galileo's *Dialogues*	4: Falling Bodies and Pendular Motion 5: Pendular Motion and Harmony	4.1, 4.2, 4.3 5.1, 5.2, 5.3, 5.4, **5.5**,	3.4, 3.5
4	Feb 11, 13, 14, 15	Galileo's *Dialogues*	6: The Law of the Lever 7: Beams, Bones and Giants	6.1, 6.2, 6.4, 6.5, 7.1, 7.2,	5.6
5*	Feb 18, 20, 21, 22*	Galileo's *Dialogues*	8: Naturally Accelerated Motion 9: The Mean Speed Theorem	**8.1**, 8.2, 8.3, 9.1, 9.2, 9.3, 10.1	6.8, 7.3
6	Feb 25, 27, 28, Mar 1	Galileo's *Dialogues*	10: Equilibrium, Force and Acceleration 11: From Conic Sections to Projectile Motion	11.1, 11.2, 11.3,	9.5, 10.2
7	Mar 4, 6, 7, 8	Begin Pascal's *Vacuum*	12: The Speed and Force of a Projectile 13: Reason, Authority and Science	12.1 **13.1**,	11.4
8	Mar **11, 13, 14, 15**	Pascal's *Weight of Air*	14: Pascal's Principle	14.1, 14.2,	Spring Break
9	Mar 18, 20, 21, 22	Pascal's *Weight of Air*	15: Submerged Bodies 16: Syringes, Siphons and Suckling Infants	15.1, 16.2, 16.4, **16.5**,	14.4, 14.5, 15.3
10	Mar 25, 27, 28, 29	Begin Newton's *Principia*	17: Life Under a Sea of Air 18: Does Nature Abhor a Vacuum 19: Mass, Momentum and Force	17.1, 17.2, **18.1**, 19.1, 19.2, **19.4**	16.6, 17.3
11*	Apr 1, 3, 4, 5*	Newton's *Principia*	20: Absolute and Relative Motion 21: Newton's Laws of Motion	20.1, 20.2, 21.1, 21.2, 21.3, **21.4**	20.3
12	Apr 8, 10, 11, 12	Newton's *Principia*	22: Conservation of Momentum 23: The Third Law and the Power of Machines	22.1, 22.2, 22.3, 22.4, 22.5, 23.1, 23.2, 23.3, 23.4, 23.5, 23.9,	22.6, 22.7
13	Apr 15, 17**, 18, 19**	Newton's *Principia*	24: Centripetal Force and Acceleration	24.1, 24.2, 24.3,	24.4
14	Apr **22**, 24, 25, 26	Newton's *Principia*	25: Newton's Rules of Reasoning 26: Planetary Motion	**25.1** 26.1, 26.2, 26.3,	Easter break!
15	Apr 29, May 1, 2, 3	Begin Einstein's *Relativity*	27: Universal Gravitation 29: The Principle of Relativity	27.1, 27.2, 27.3, 27.5 29.1,	29.2
16	May 6, 8, 9, 10	Einstein's *Relativity*	30: The Absolute Speed of Light 31: Lorentz Transformations	30.1, 30.2, 30.3, 30.4 31.1, 31.2, 31.3, 31.4, 31.5,	31.7
17	May 13, 15, 16, 17	Final Exam			

	Mon.	Tue.	Wed.	Thurs.	Fri.
7:40	matins	matins	matins	matins	
8:00	OH/Lab	PHY 215 Lab (S113)	OH/Lab	PHY 215 Lab (S113)	OH/Lab
8:30					
9:00	PHY 201 L2 (S115)		PHY 201 L2 (S115)		PHY 201 L2 (S115)
9:30					
10:00	chapel		chapel		chapel
10:30	PHY 201 L1 (S109)		PHY 201 L1 (S109)		PHY 201 L1 (S109)
11:00		chapel		chapel	
11:30				PHY 201 L1 (S109)	
12:00					
12:30	OH/Lab	OH/Lab	OH/Lab		OH/Lab
1:00					
1:30				PHY 201 L2 (S115)	
2:00					
2:30				OH/Lab	
3:00					
3:30	Meetings				
4:00					
4:30					
5:00					